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Title: Tests and Field Mapping of RODM01 Septum Magnet

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Tests and Field Mapping of RODM01 Septum Magnet

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Abstract

RODM01 is a septum magnet located in the extraction region of LANSCE Proton Storage Ring. Tests and field mapping of RODM01 Set #2 were performed on 02/04/2020 by members of AOT-MDE, AOT-RFE and AOT-AE Groups. Setups of test and mapping are presented in Figures 1-5. Magnetic field measurements was performed using Hall probe (see Figure 2). Results of measurements are almost identical to that of RODM01 Set #1 performed in July 2018. Trim coil current of magnet selected to be as - 9.28 A.

1. Trim Coil Connection

Trim coil connections and results of measurements are illustrated in Figures 4-5 and Table 1. A Kepco BOP-20-20M (20V, 20A) bipolar DC power supply was connected to the Trim coil on the RODM01 septum magnet with the RED cable on OUT, and BROWN on COM. There was a series current viewing resistor (CVR) to measure magnitude and direction of current through Trim with the ratio 50 mV = 20 A. In order to achieve the desired field effect with the Trim coil the output current was set to negative.

Table 1. Trim coil current and current viewing resistor (CVR) voltage.

Trim Current (A)	CVR Voltage (mV)
0	0
-9	-22.5
-9.28	-23.2
-18	-45

2. Test Measurements

The following test measurements were performed:

- Pressure drop versus flow rate
- Voltages, field, temperatures and resistance versus current at 20 GPM flow rate
- Voltages, field, temperatures and resistance versus current at 15 GPM flow rate

Results of measurements are presented in Figures 6-21.

3. Magnet Mapping

Within mapping, the following limits were applied:

- The water flow was in the 15 GPM to 20 GPM range with the inlet pressure not exceeding 200 psi
- The flow rate as well as the inlet and outlet pressures were monitored closely and checked regularly to ensure the magnet is adequately cooled (about every 5 to 10 minutes, or if the cooling water noise level or pitch change)
- The cooling water hose connections were monitored
- The power supply current trip limit was set at 2200 A, with the mapping currents kept at 2150 A or below
- The power supply voltage trip limit was set at 40 V
- Prior to mapping run, verification was done that the current, voltage and flow trips were set properly and checked to be all functional.

3.1 Magnet Mapping along Circulating Beam Center

Magnet current was selected to be 2150 A. Magnetic probe was put transversely along Nominal Circulating Beam Center (see Fig. 2). Longitudinal interval of probe position variation was ± 700 mm from the magnet center (total interval 1400 mm) with longitudinal step $\Delta z = 5$ mm (281 points). Trim coil current was varied within 0…. -15A. Integral field along the Nominal Circulating Beam Center was evaluated:

$$\int_z B_y(z)dz = \Delta z \sum_{i=1}^{N=281} B_i \tag{1}$$

Results of measurements are presented in Figs. 22 - 23. From measurement it was determined, that trim coil current should be selected as – 9.28 A to keep integral field along circulating trajectory close to zero.

3.2 Magnet Mapping along Kicked Beam Center

Keeping magnet current to be 2150 A and trim coil current -9.28 A, the probe was put transversely along Nominal Kicked Beam Center (see Fig. 2). The vertical component of the field B_y was measured along Nominal Kicked Beam Center. Longitudinal interval of probe position variation was $\pm$ 500 mm from the magnet center (total interval 1000 mm) with longitudinal step $\Delta z = 5$ mm (201 points). Integral field along kicked beam trajectory was calculated (see Fig. 24).

$$\int_z B_y(z)dz = \Delta z \sum_{i=1}^{N=201} B_i = 484.0\ kG\,cm\ . \tag{2}$$

3.3 Magnet Mapping in the middle of Kicked Beam Center

Finally, the probe was put in the center of magnet along Nominal Kicked Beam Center. The current was changed from 2150 A to zero, and back, from 0 to 2150 A with interval of 100 A. The vertical component of the field B_y was measured. Results of measurements are presented in Figs. 25, 26.

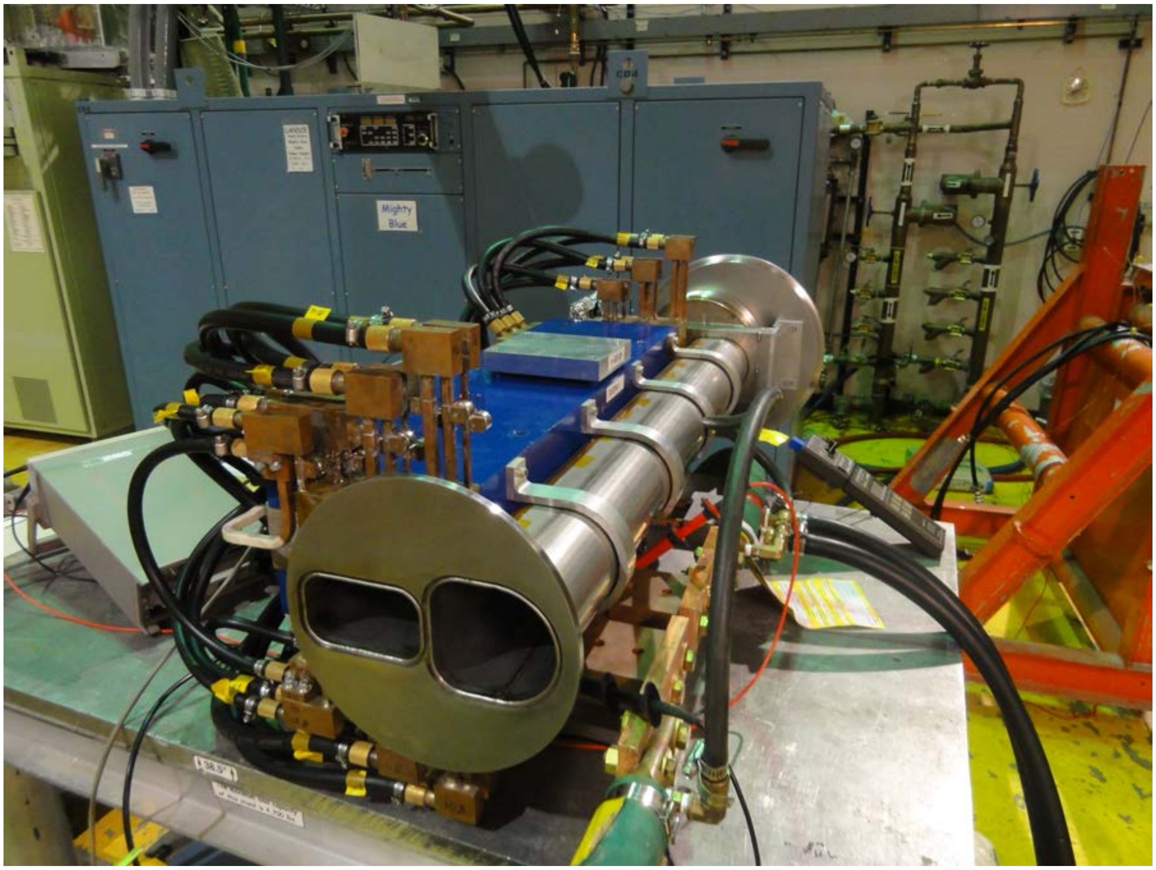


Figure 1: RODM01 Set # 2 Septum Magnet.

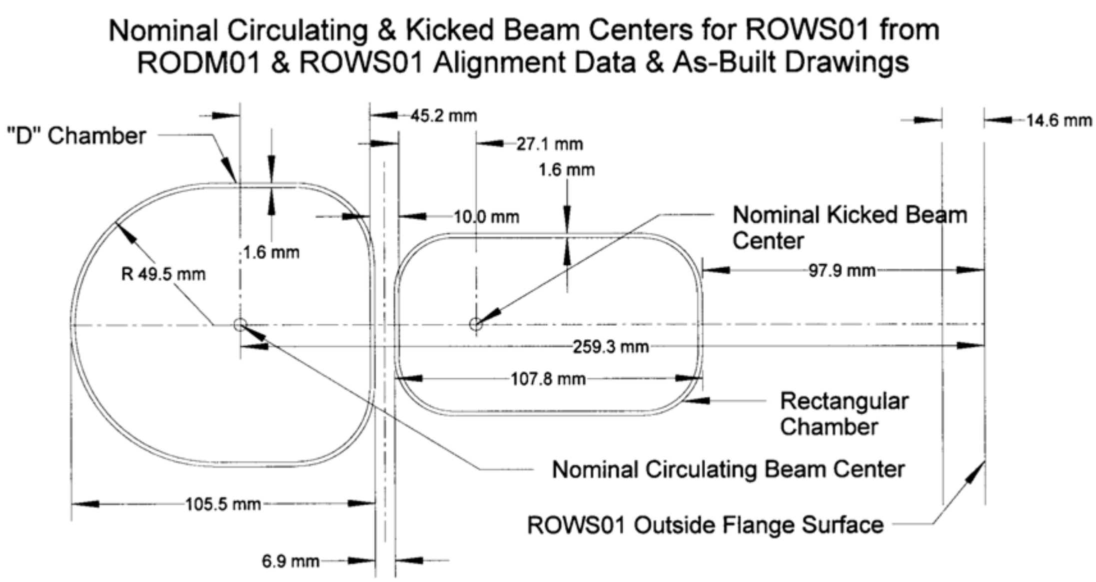


Figure 2: Alignment of RODM01 septum and vacuum chambers with superimposed positions of the nominal centers of the circulating and extracted beams (Dan Fitzerald, PSR Tech Note 95-015).

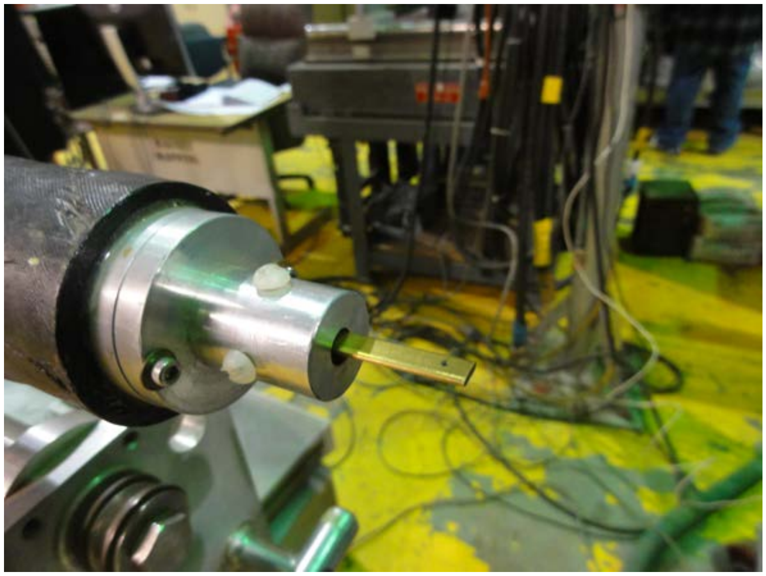
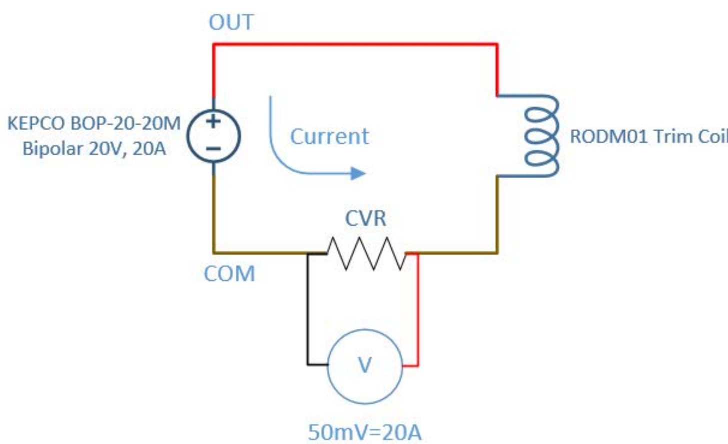


Figure 3: Magnetic probe.

(a)



(b)

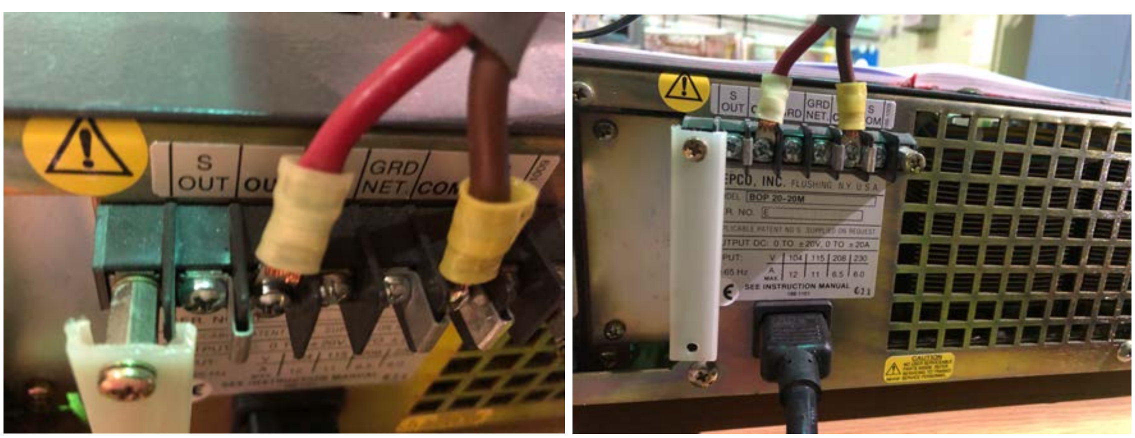


Figure 4: Trim power supply setup: (a) schematics, (b) contacts at power supply.

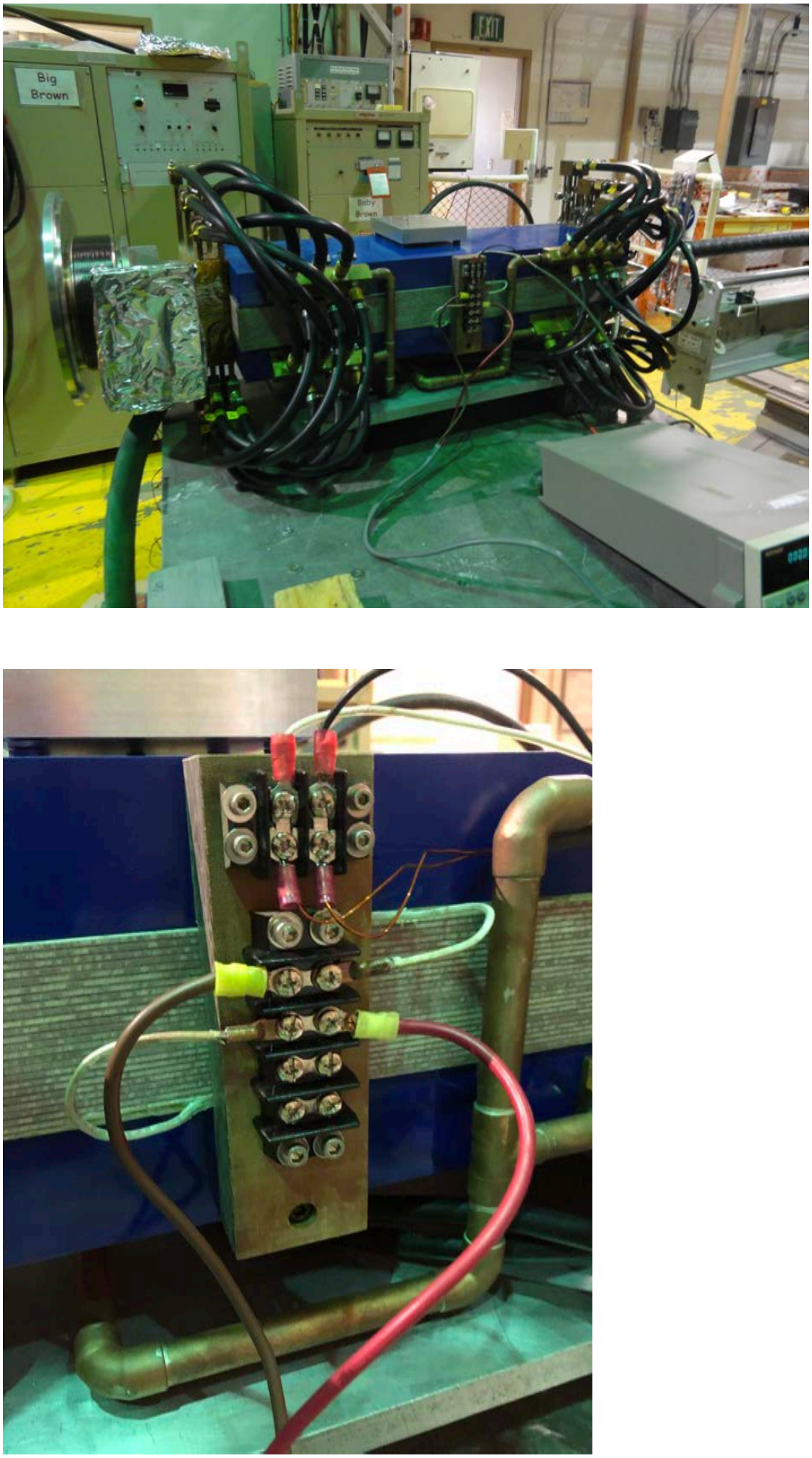


Figure 5: Trim coil connections at magnet.

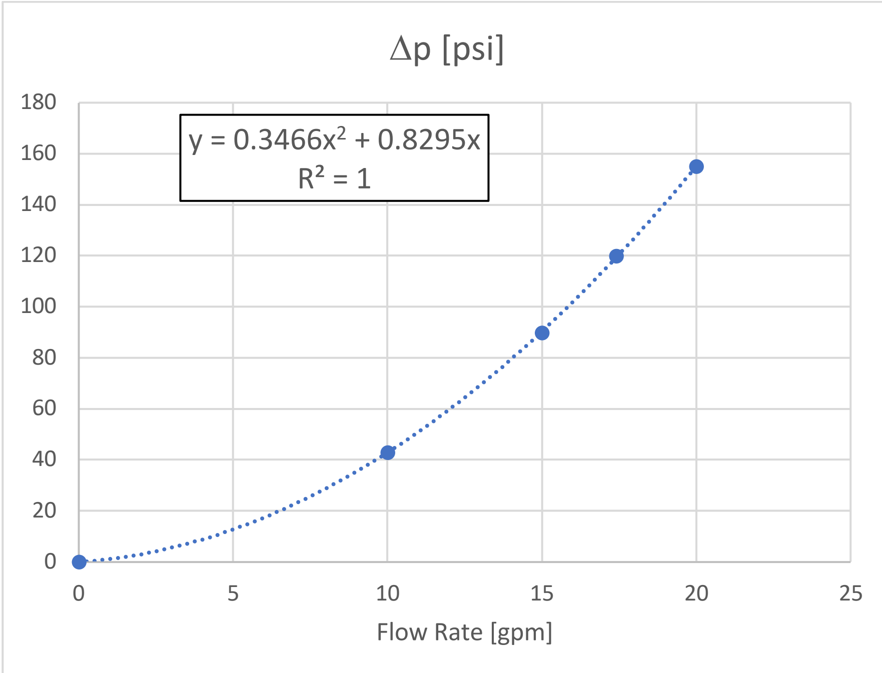


Figure 6. Pressure drop versus Flow Rate.

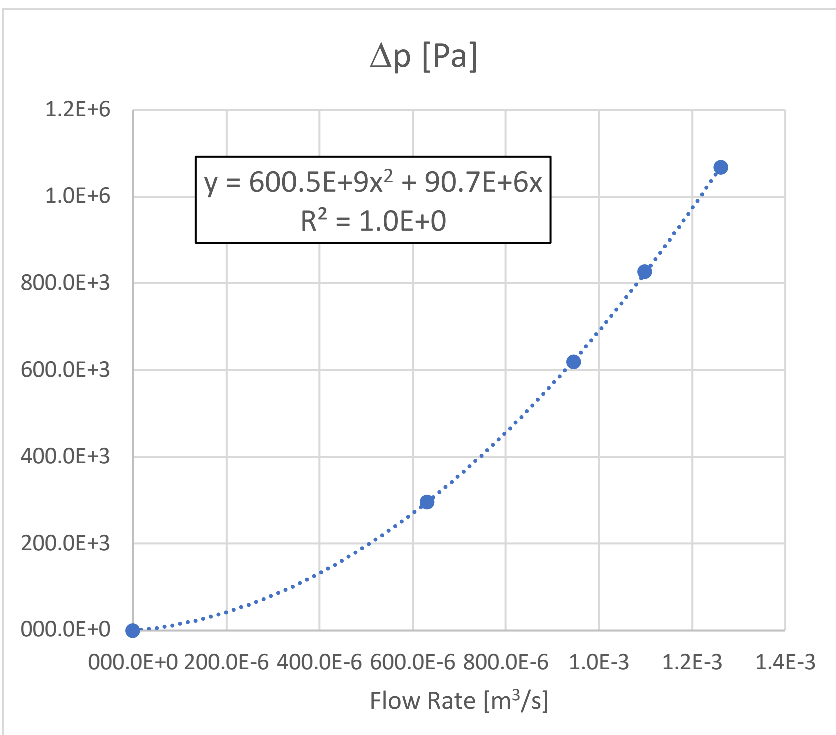


Figure 7. Pressure drop versus Flow Rate.

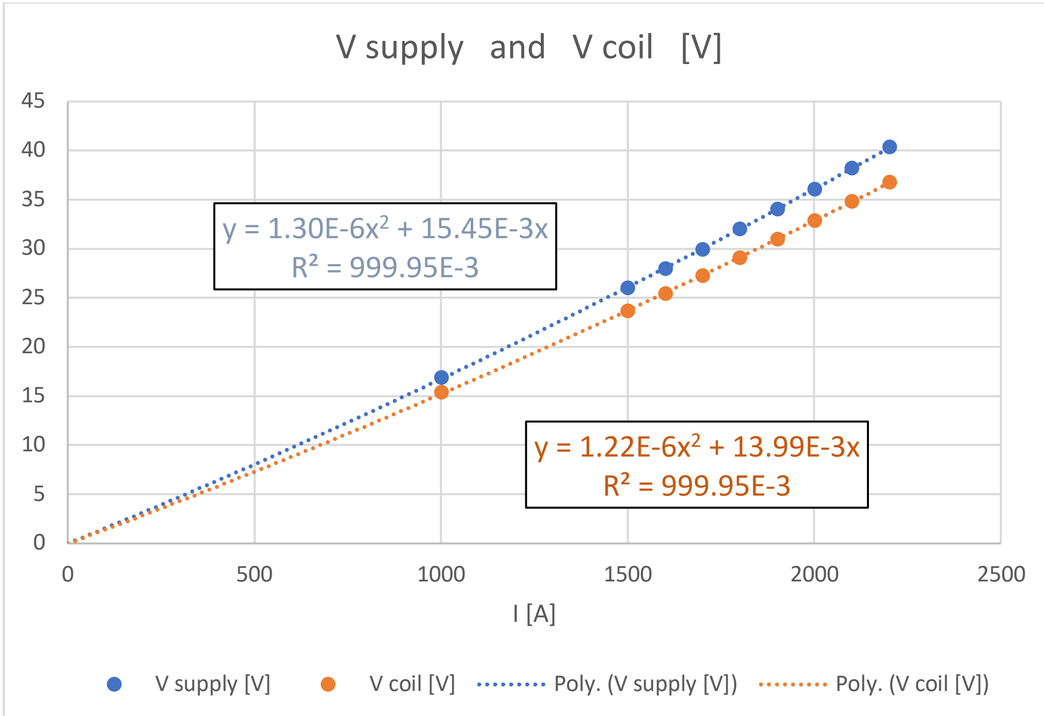


Figure 8: Voltage versus current at 15 GPM flow rate.

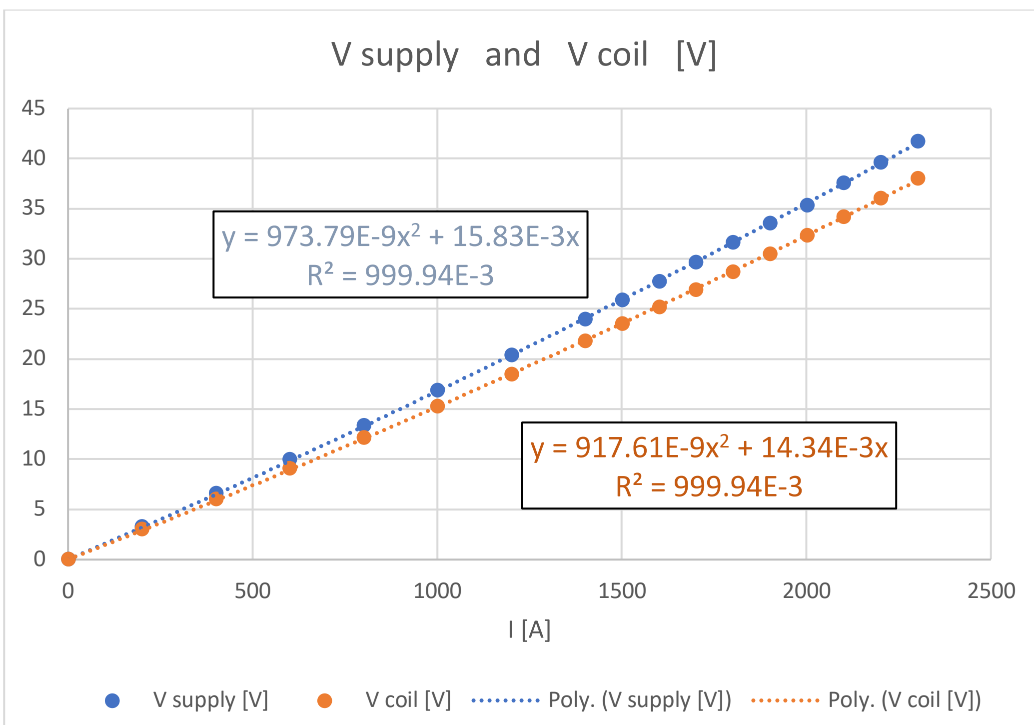


Figure 9: Voltage versus current at 20 GPM flow rate.

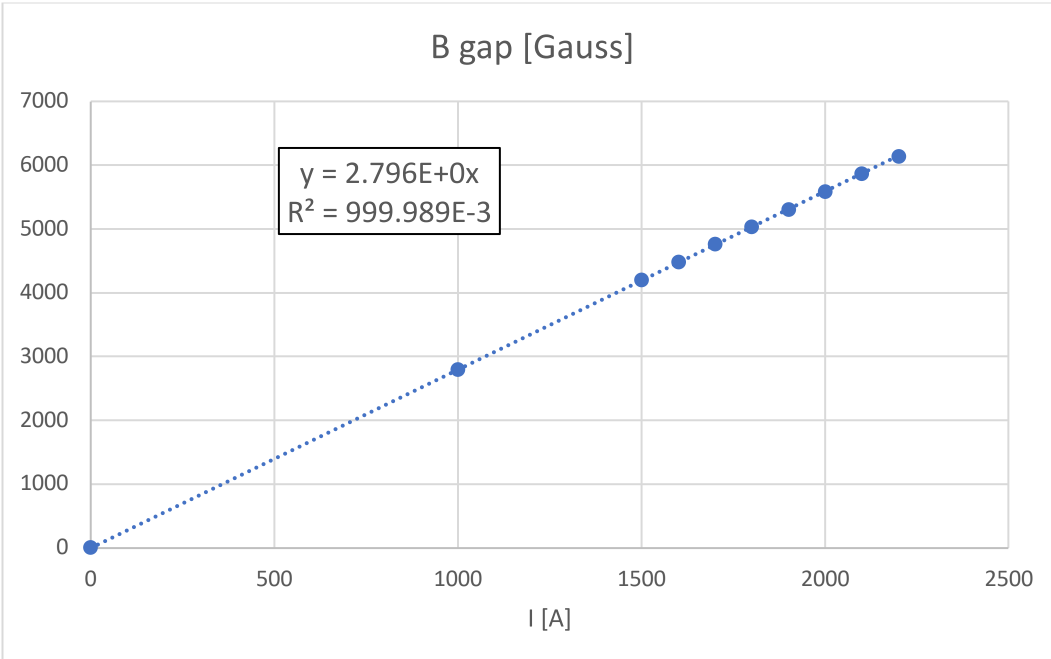


Figure 10: Vertical field component B_y along nominal kicked beam center versus current at 15 GPM flow rate.

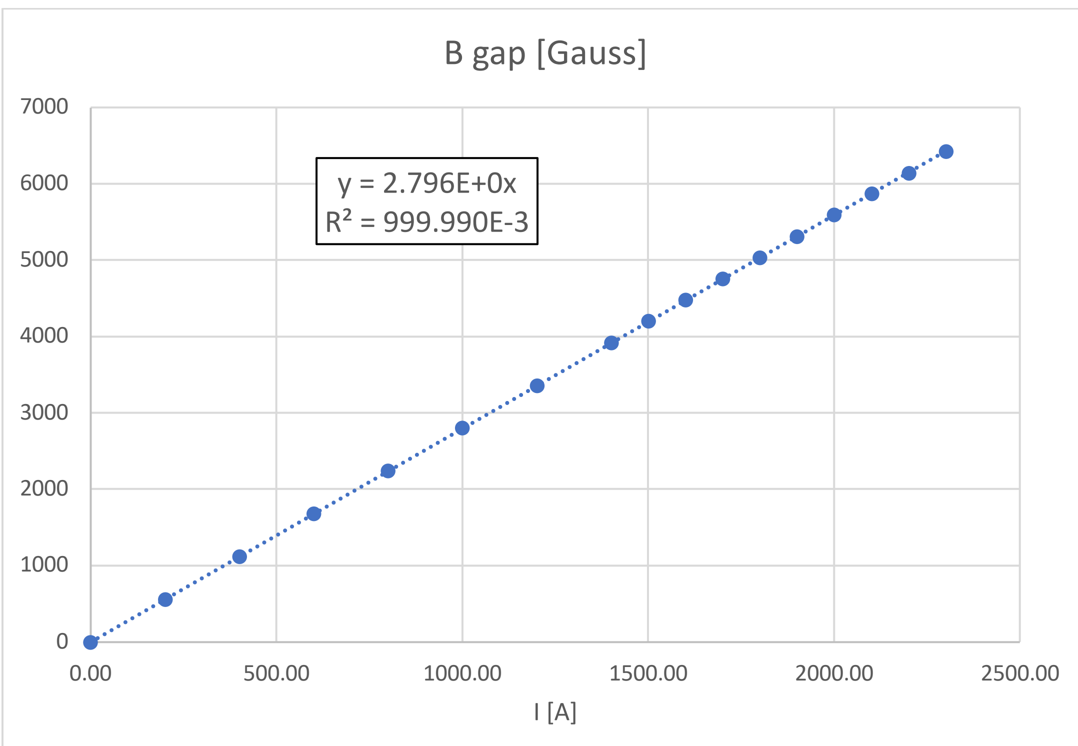


Figure 11: Vertical field component B_y along nominal kicked beam center versus current at 20 GPM flow rate.

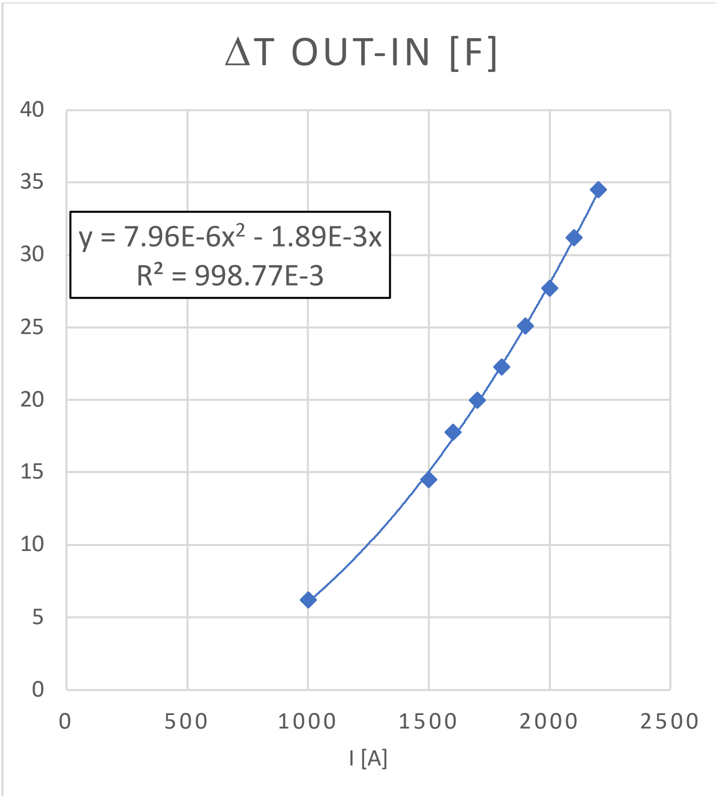


Figure 12: Temperature versus current at 15 GPM flow rate.

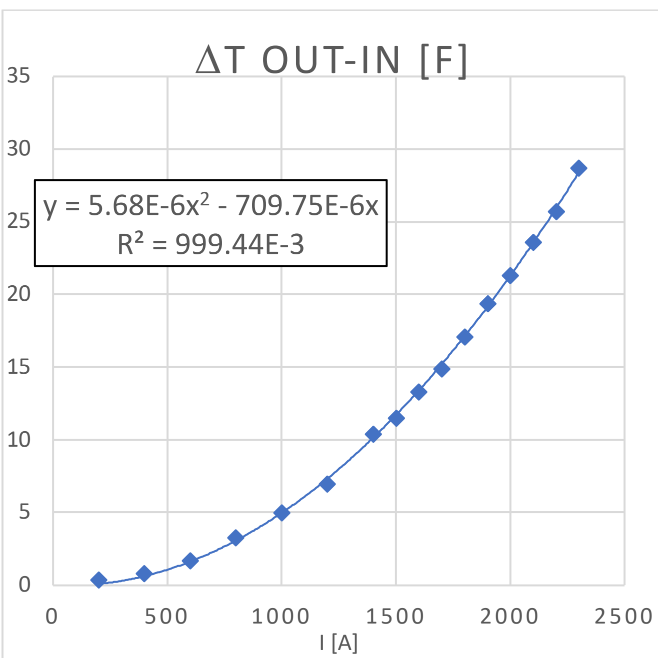


Figure 13: Temperature versus current at 20 GPM flow rate.

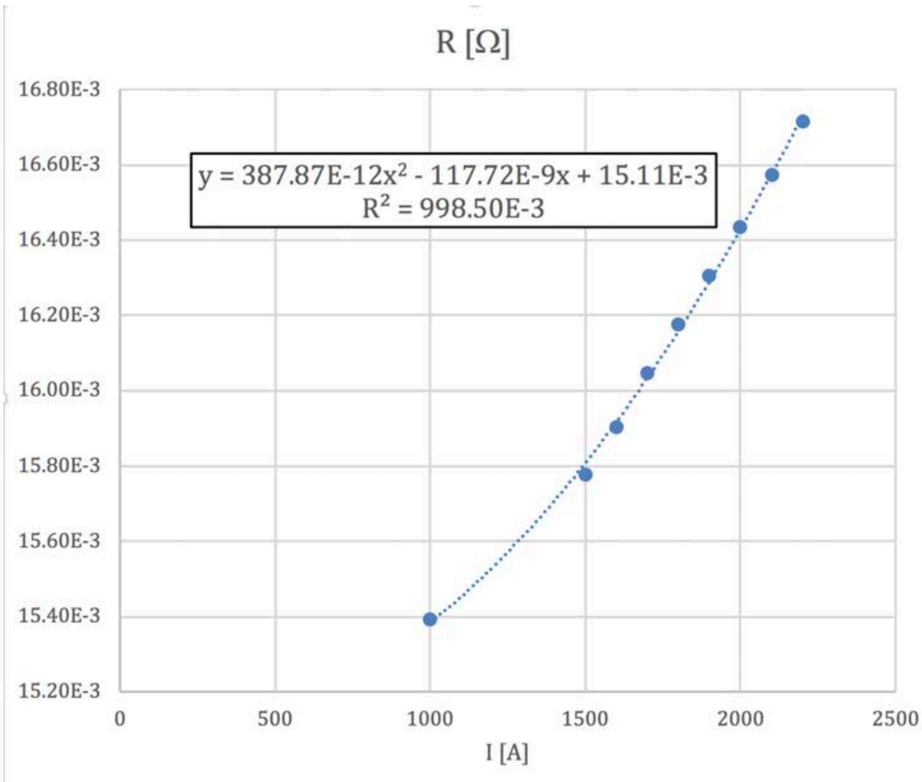


Figure 14: Resistance versus current at 15 GPM flow rate.

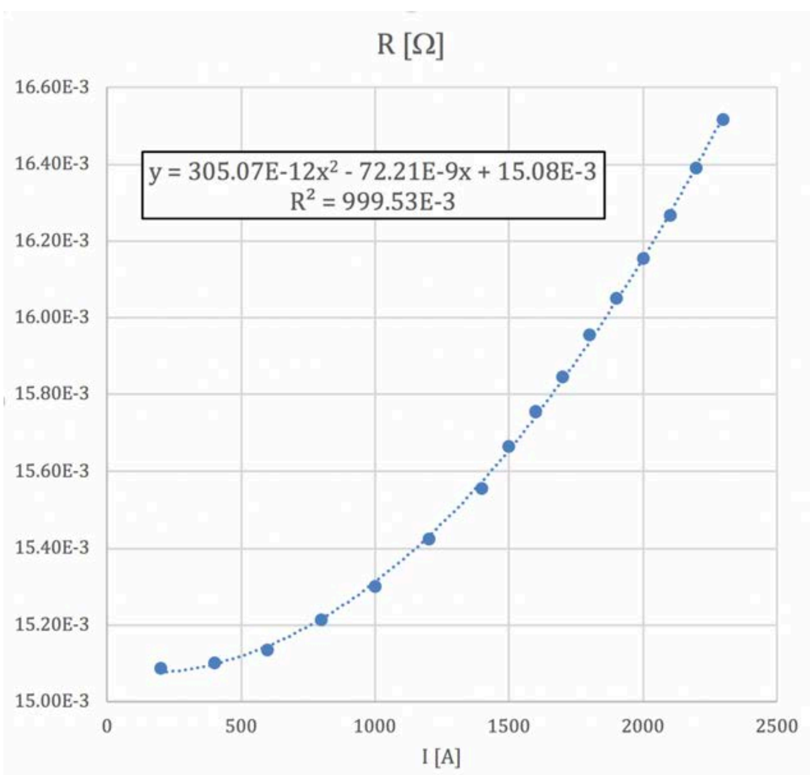


Figure 15: Resistance versus current at 20 GPM flow rate.

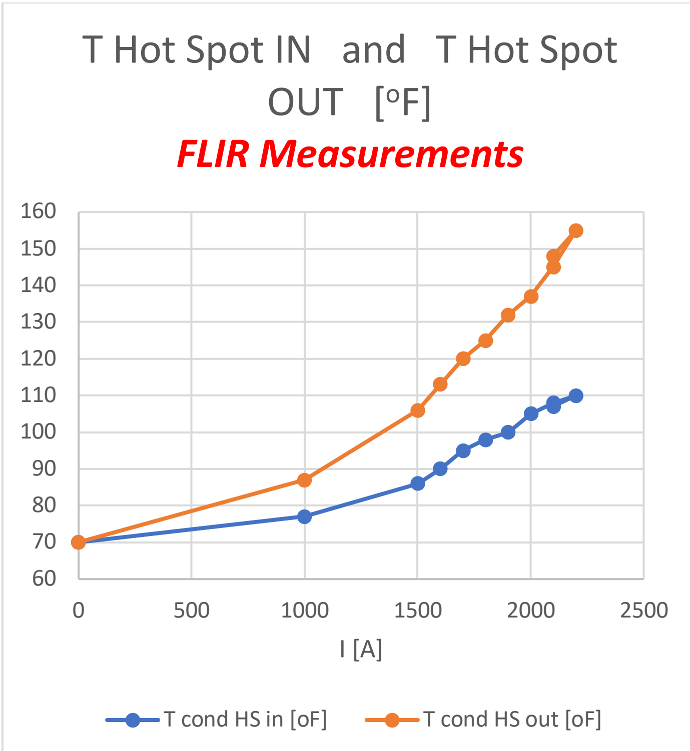


Figure 16: Hot spot IN and OUT temperature versus current at 15 GPM flow rate.

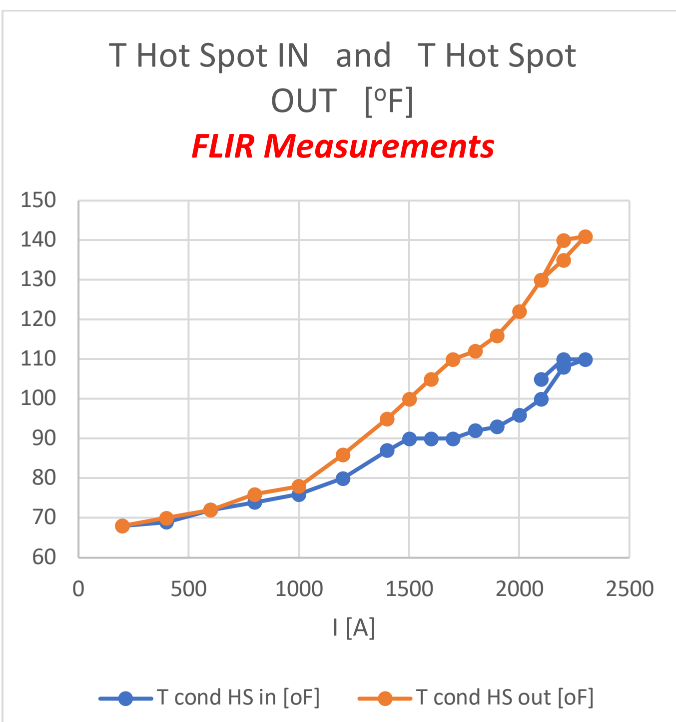


Figure 17: Hot spot IN and OUT temperature versus current at 20 GPM flow rate.

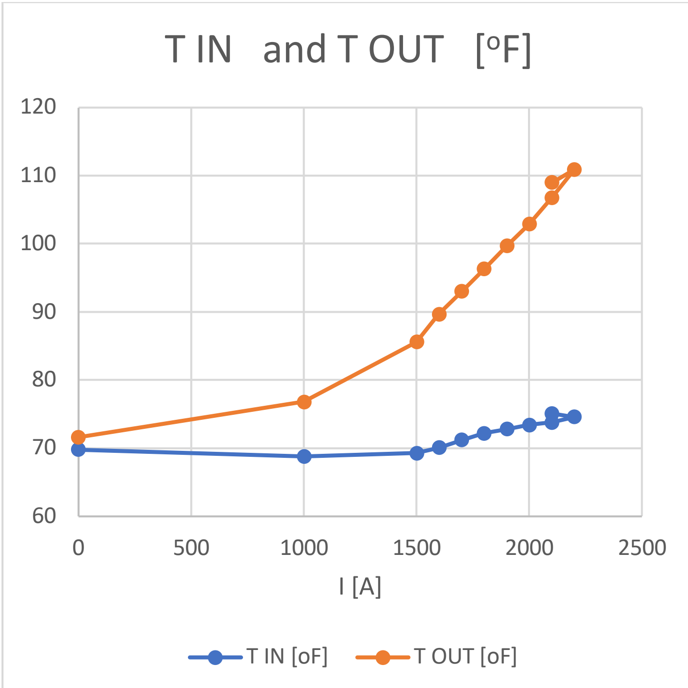


Figure 18: Temperature IN and OUT versus current at 15 GPM flow rate.

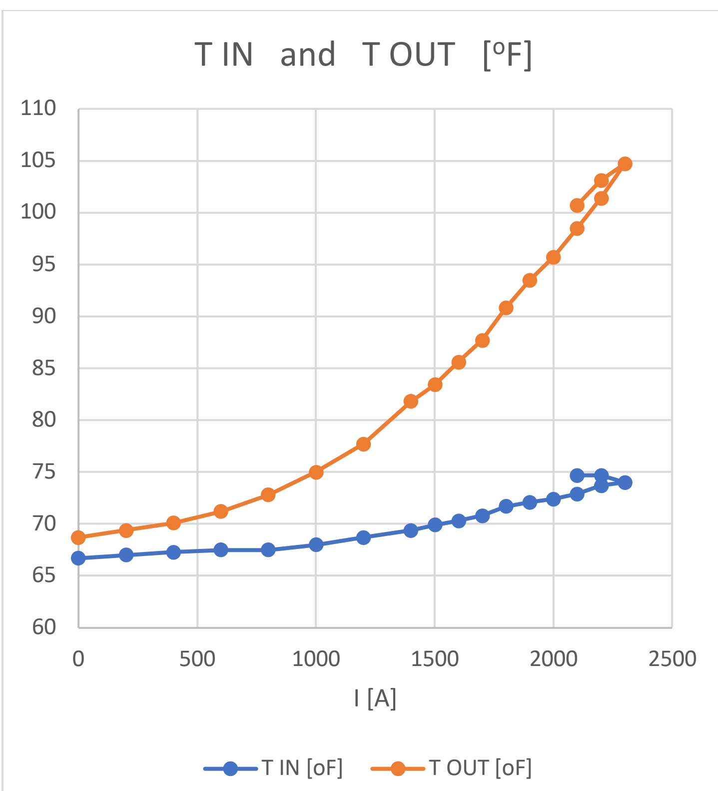


Figure 19: Temperature IN and OUT versus current at 20 GPM flow rate.

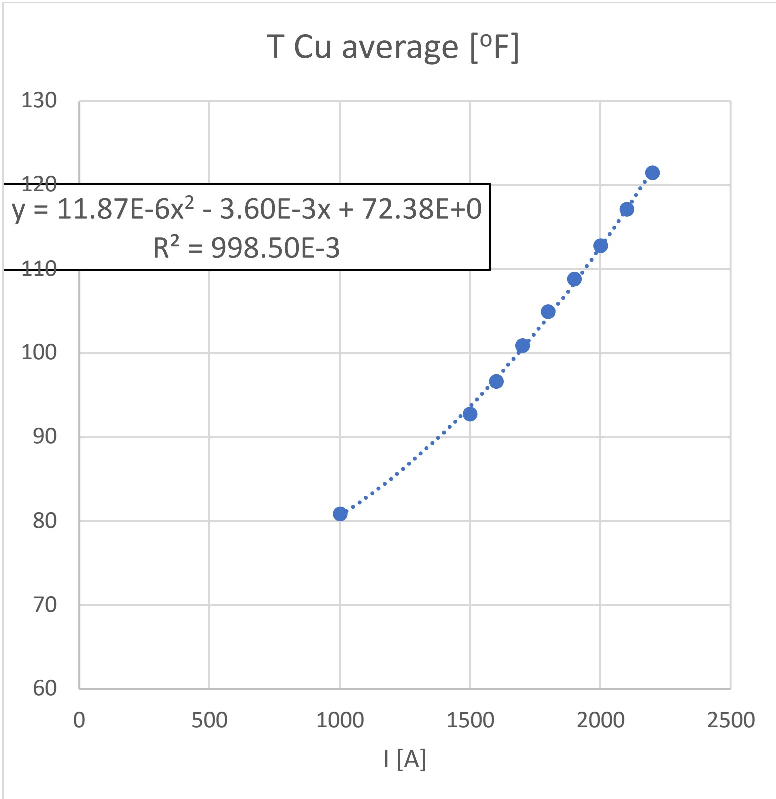


Figure 20: Cu temperature versus current at 15 GPM flow rate.

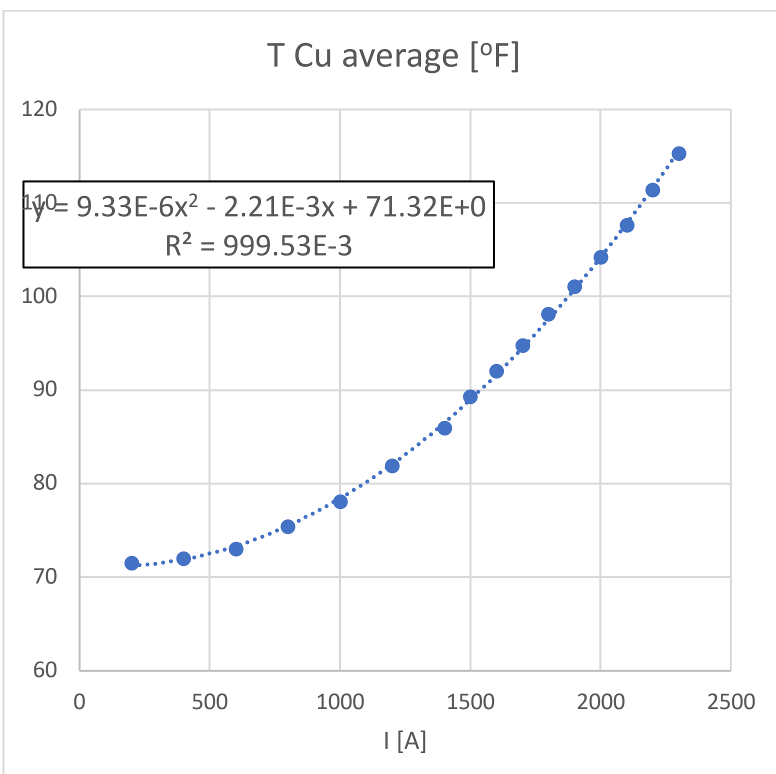


Figure 21: Cu temperature versus current at 20 GPM flow rate.

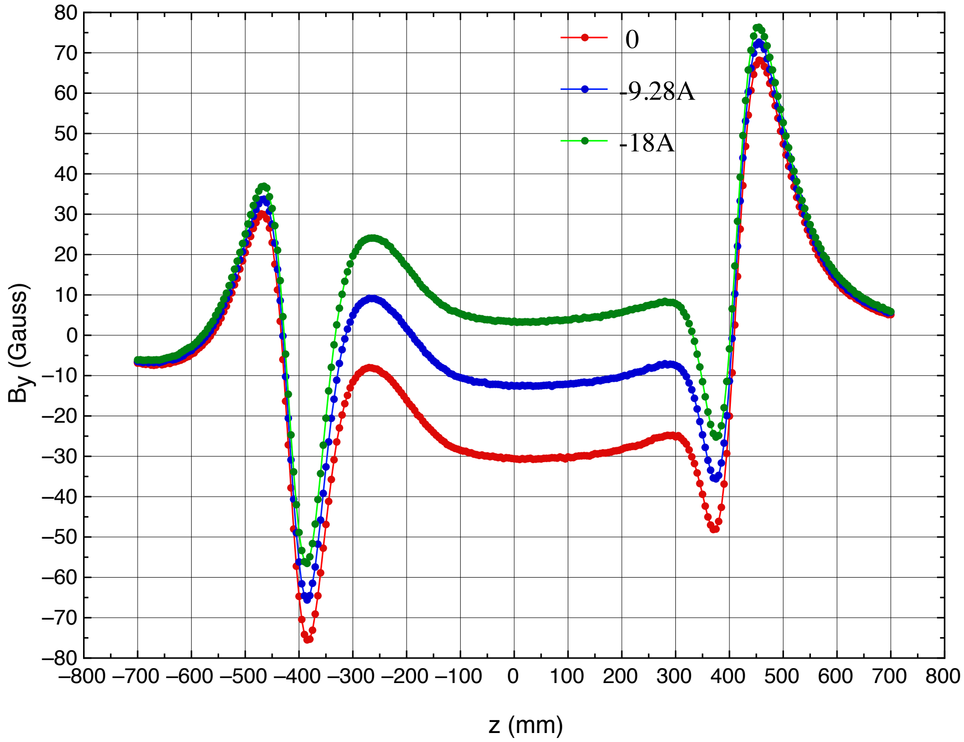


Figure 22: Vertical field component B_y along nominal circulating beam center with various trim coil current.

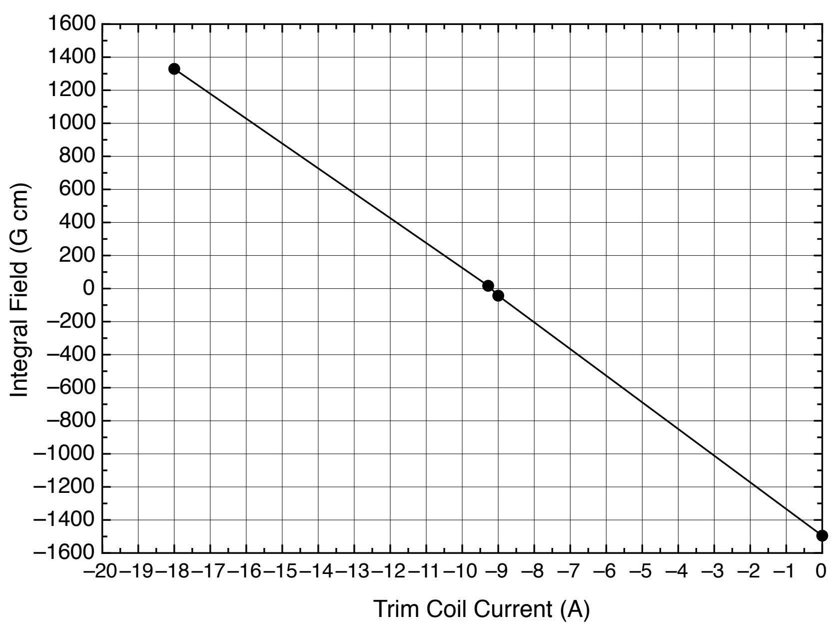


Figure 23: Integral field along nominal circulating beam center as a function of trim coil current.

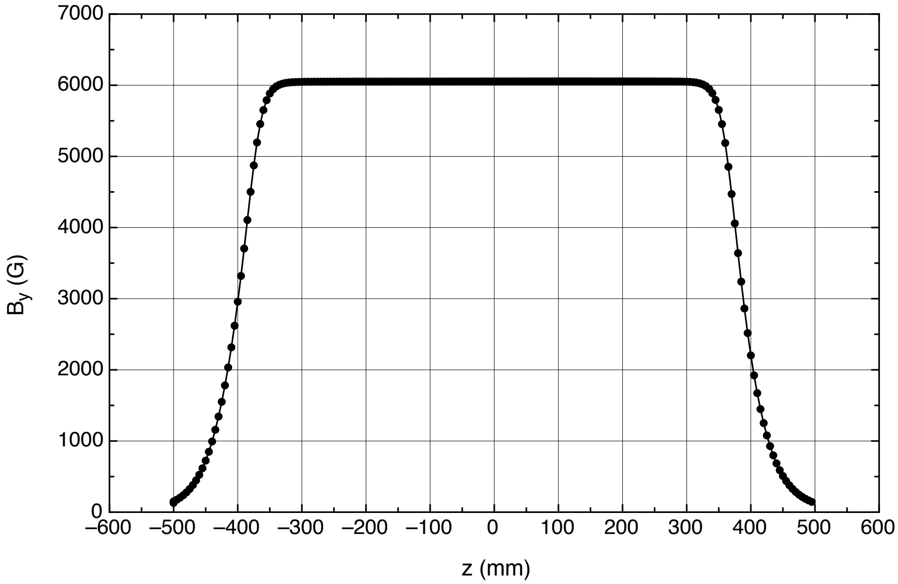
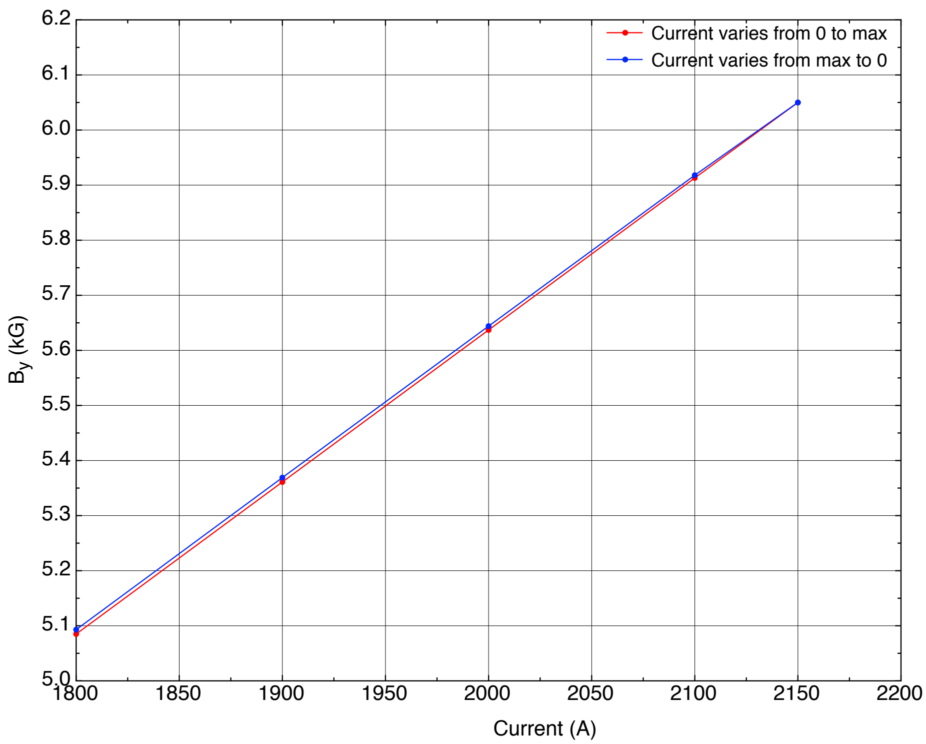


Figure 24: Vertical field component B_y along nominal kicked beam center with trim coil current - 9.28 A. Integral field is 484.0 kG cm.



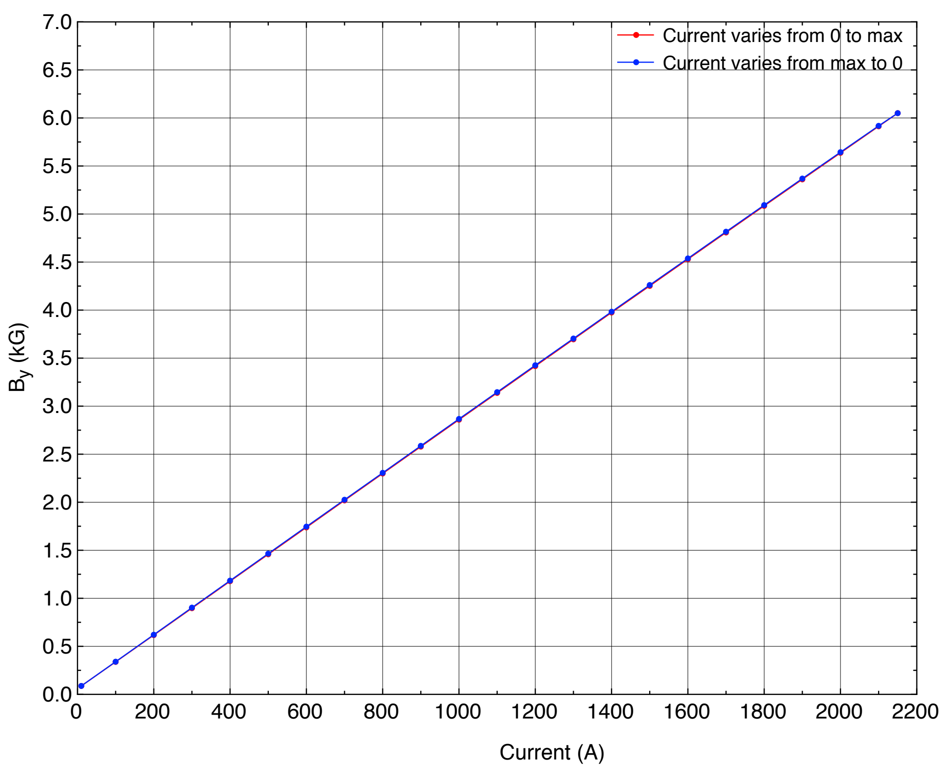


Figure 25: Field in the center of magnet along nominal kicked beam center as a function of magnet current (trim coil current -9.28 A).

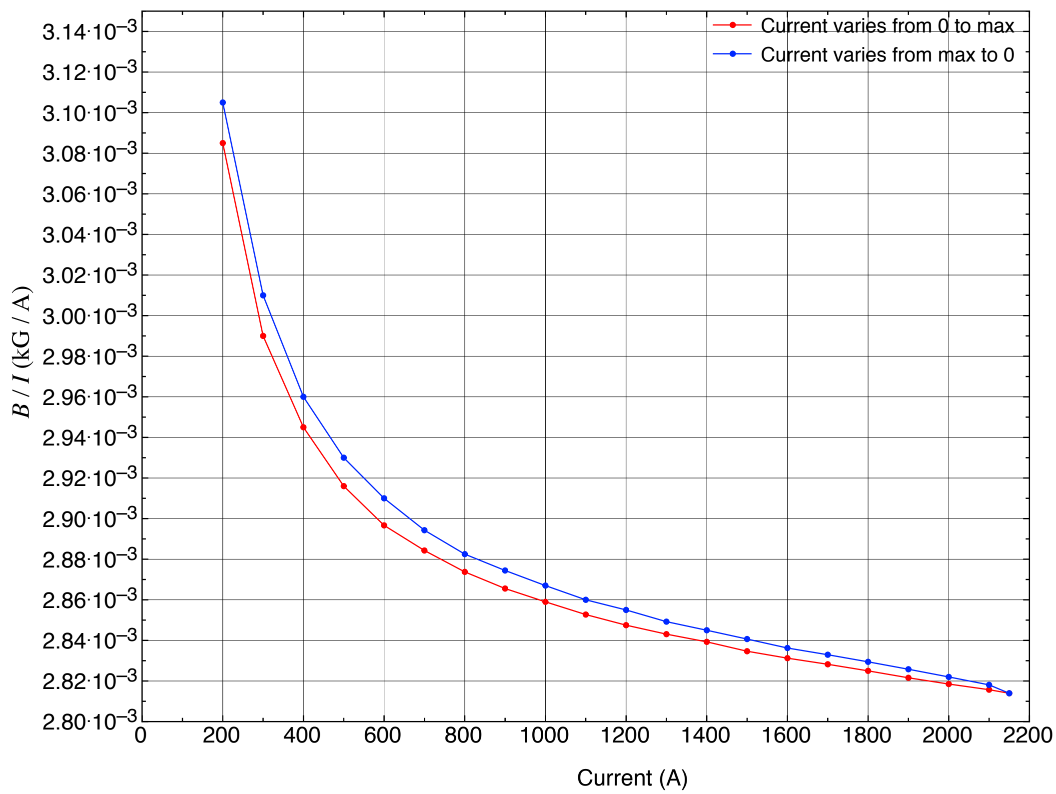


Figure 26: Ratio of field to current in the center of magnet along nominal kicked beam center as a function of magnet current (trim coil current -9.28 A).